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DIVERSITY OF SPIDERS IN BOREAL AND ARCTIC ZONES

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ABSTRACT. During the last two decades a great number of studies dealing with arctic and boreal spiders have been published, both in the Palaearctic and the Nearctic. Such an increase in information makes it possible to analyze basic patterns of spider diversity in the North as well as to show areas where further studies are still necessary. The number of species found in faunas of larger areas north of 60°N varies from 620 (Finland) to 250 (Polar Urals) and 300 (Yukon), when island faunas are excluded. Two areas, divided by the Bering Strait, Northeastern Siberia and north-western North America have marked proportion of endemic taxa (ca. 8 %) belonging to several spider families. Considerable number of endemic spiders are known also in Middle Siberia. The number of spiders in local faunas of the boreal zone varies around 300 species. Study of species composition in more than 20 local northern faunas reveals that proportion of Lycosidae species in each local fauna varies in smallest range (7–12 % of all species found) in comparison to other families. Thus Lycosidae can be used as an indicator group of general species diversity of spiders in local faunas.

Keywords: Holarctic, diversity, indicators, northern faunas, Araneae

Spiders comprise one of the largest (5–6th) orders of animals. Spiders are also one of the best objects to study and monitor species diversity in terrestrial ecosystems, especially at high latitude (cf. Marusik & Koponen 2000). Since the early 1980's a marked number of taxonomic and faunistic reports on arctic, boreal and temperate spiders have been published both in the Palaearctic and Nearctic regions (Mikhailov 1997; Platnick 2001). This has resulted in areas that were previously almost or entirely unknown, such as the Ural mountains, Krasnoyarsk Province, Yakutia, NE Siberia, Tuva, Yukon Territory, Manitoba and British Columbia, becoming rather well-known (see Marusik et al. 2000). More than 300 spider species have been described from the Arctic and boreal zones of Asia and North America during the last 15 years. Such an increase in information makes it possible to analyze basic patterns of spider diversity in the North Holarctic, and to find the most important areas for further study. The present analyses are based on literature data (Koponen 1996; Marusik & Koponen 2000; Marusik et al. 2000).

Well-studied areas and similarity.—Some well-studied faunas in different larger areas in the northern Holarctic are shown in Fig. 1. Species number varies in mainland faunas north of 60°N from 620 (Finland) to 250 (Polar Urals) and 300 (Yukon). The number of found families varies also considerable, with only 14 in the Polar Urals, 19 in the northern parts of Siberia and as high as 29 in Norway. For special features of the island faunas and their similarities, see Koponen (1993, 1995). The number of species found depends on the duration and activity of study in each area. For example, the spider fauna of Finland (620 species) has been studied more or less actively for many decades, while NE Siberia with the second largest fauna (550 species) has been investigated only for 15 years. On the basis of the known species numbers, in any larger area lying between 60° and 70°N there seem to be up to 650 spider species. Species number is higher south of the boreal zone, for example, about 900 species are

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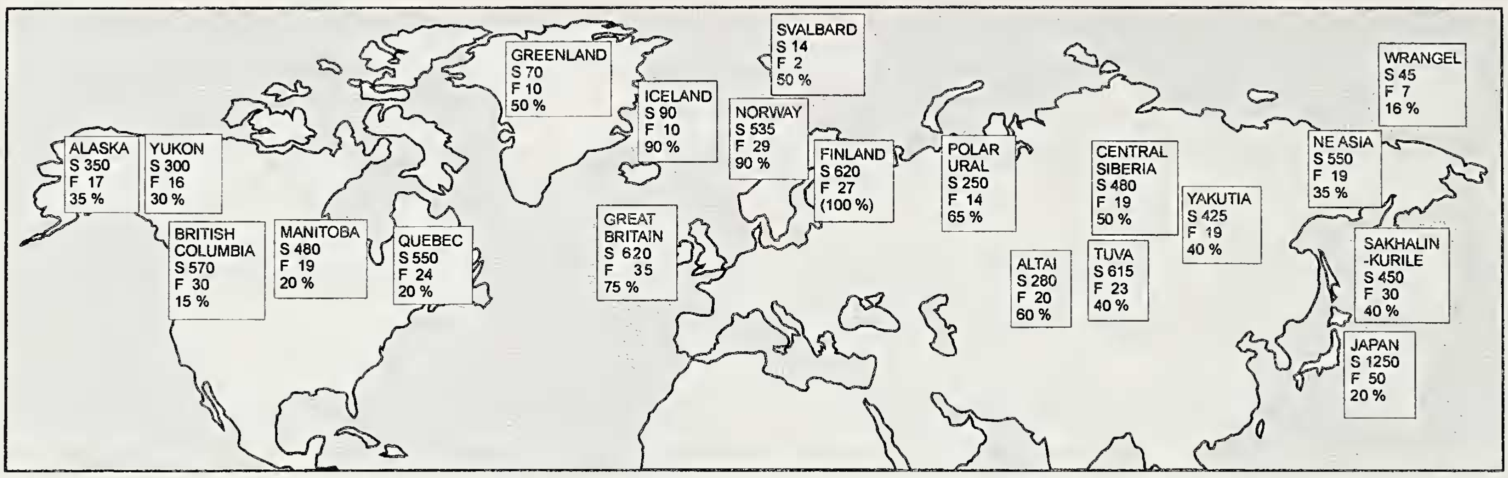

Figure 1.—Diversity of certain well-known spider faunas (S = number of species, F = number of families) and faunal similarity (as percentage of jointly occurring species) between the faunas in question and Finland (from Marusik & Koponen 2000).

known in Slovakia (Gajdos et al. 1999) and 820 in Washington (Crawford 1988 and pers. comm.).

The similarity of northern faunas is shown in Fig. 1, based mainly on data by Koponen (1996) and Marusik & Koponen (2000). The faunal similarity (as a percentage of jointly-occurring species) between Finland (a well-studied area) and select circumpolar faunas varies from 90 % in North Europe to 60 % (Altai Mts) or less in Siberia, and 15–20 % in boreal Canada. For comparison, the faunal similarity between Finland and Japan (a species and family rich area) is 20 %. The faunal similarity is correlated with the distance between sites at the same latitude; for example, 90 % similarity between Finland and Norway (ca. 700 km distance), 65 % Finland—Polar Ural (2000 km), 50 % Finland—Central Siberia (3700 km), and 40 % Finland—Yakutia (5000 km).

Faunal similarity of closely situated Beringian areas, NE Siberia and NW America is only 40 %; the proportion of jointly-occurring species varies between 36 % and 70 % in different spider families (Marusik & Koponen 2000). Extrapolating from the level of similarity between northern areas, the total worldwide number of spider species living north of 60°N latitude is about 1400–1500 species. This figure means about 4 % of the known spider species (Platnick 2001) live in an area that is 10 % of the ice-free land surface of the Earth. But about 18 % of all known linyphiids, the dominant northern spiders (Tables 1–2), live north of 60°N. When considering the faunal similarity and total species number, difficulties concerning the identity of many problematic species in the huge circumpolar area must be borne in mind (see Koponen 1996).

Poorly studied areas.—There are still some large areas in the northern Palaearctic that could be called as unstudied "white spots" and therefore require faunistic investigations (Marusik & Koponen 2000). These include in Asia (Fig. 2): 1. West Siberia (from Ob to Yenisei), 2. Northwest Yakutia (from Kotui to Olenyok), 3. northern parts of Verkhoyanski and Cherski Mt. ranges, 4. northern part of Khabarovsk province and South Yakutia and 5. Koryakiya.

Endemism.—There are two distinct centers of endemism within the boreal zone. The highest proportion of endemic spiders is found in NE Siberia, and also in the closely situated NW North America by the Bering Strait, where about 8 % of species are endemic (Marusik & Koponen 2000). In NE Siberia more than 30 endemic linyphiid and dictynid species, restricted to the boreal zone, are known. The percentage of endemic species of staphylinid beetles in NE Siberia and NW North America is about the same (11 % and 10 % respectively; Ryabukhin 1998). The main reason for high endemism in these areas is the glaciation history of the Beringian area, it was not covered by continuous ice (e.g. Pielou 1991).

A marked number of endemic spider species is known also in Middle Siberia between Altai-Tuva (50°N) and Middle Yenisei (65°N) with about 20 endemics belonging to Linyphiidae, Lycosidae, and Gnaphosidae (Marusik et al. 2000 and Marusik, pers. obs.). In general, the percentage of endemic spiders in

Table 1.–Faunal structure of 8 local faunas in boreal zone (only species-rich families shown): 1. Tvärminne, Finland, 60°N (Palmgren 1972); 2. Nizhnesvirskiy Reserve, Russian Karelia, 60°50′N (Oliger 1996); 3. Mäntyharju, Finland, 61°15′N (Palmgren 1977); 4. Kivach Reserve, Russian Karelia, 62°18′N (Cellarius 1993); 5. Mirnoye, West Siberia, 62°20′N (Eskov 1998 and Marusik unpublished data); 6. Aborigen, East Siberia, 62°N (Marusik et al. 1992); 7. Kuusamo, Finland, 66°N (Koponen & Viramo 1998); 8. Kevo, Finland, 69°45′N (Koponen 1984); see also Fig. 2.

	1. Tvär-minne	%	2. Ni-zhnes-virskiy	%	3. Mänty-harju	%	4. Kivatch	%	5. Mir-noye	%	6. Abori-gen	%	7. Kuusa-mo	%	8. Kevo	%	range of %	max./min.
Araneidae	20	5	24	7	20	6	17	6	10	4	16	4	13	5	11	6	4–7	1.75
Clubionidae	17	4	12	3	9	3	7	3	9	3	7	2	5	2	4	2	2–4	2
Dictynidae	4	1	8	2	5	2	3	1	6	2	10	3	4	2	4	2	1–3	3
Gnaphosidae	28	7	28	8	21	5	19	7	15	5	30	8	10	4	10	6	4–8	2
Hahniidae	6	1	4	1	5	2	4	1	5	2	2	1	5	2	2	1	1–2	2
Linyphiidae	176	41	141	40	145	46	129	47	156	56	198	55	135	56	98	59	40–59	1.48
Lycosidae	37	9	35	10	24	8	25	9	23	8	24	7	20	8	14	8	7–10	1.42
Philodromidae	14	3	9	3	8	3	6	2	3	1	10	3	4	2	4	2	1–3	3
Salticidae	33	8	22	6	16	5	14	5	11	4	25	7	9	4	3	2	2–8	4
Tetragnathidae	11	3	12	3	9	3	8	3	5	2	2	1	2	1	1	1	1–3	3
Theridiidae	32	8	21	6	24	6	19	7	9	3	13	4	12	5	5	3	3–8	2.7
Thomisidae	17	4	18	5	15	5	9	3	15	5	12	3	11	5	5	3	3–6	2
Total number	425		354		315		275		277		357		240		165			

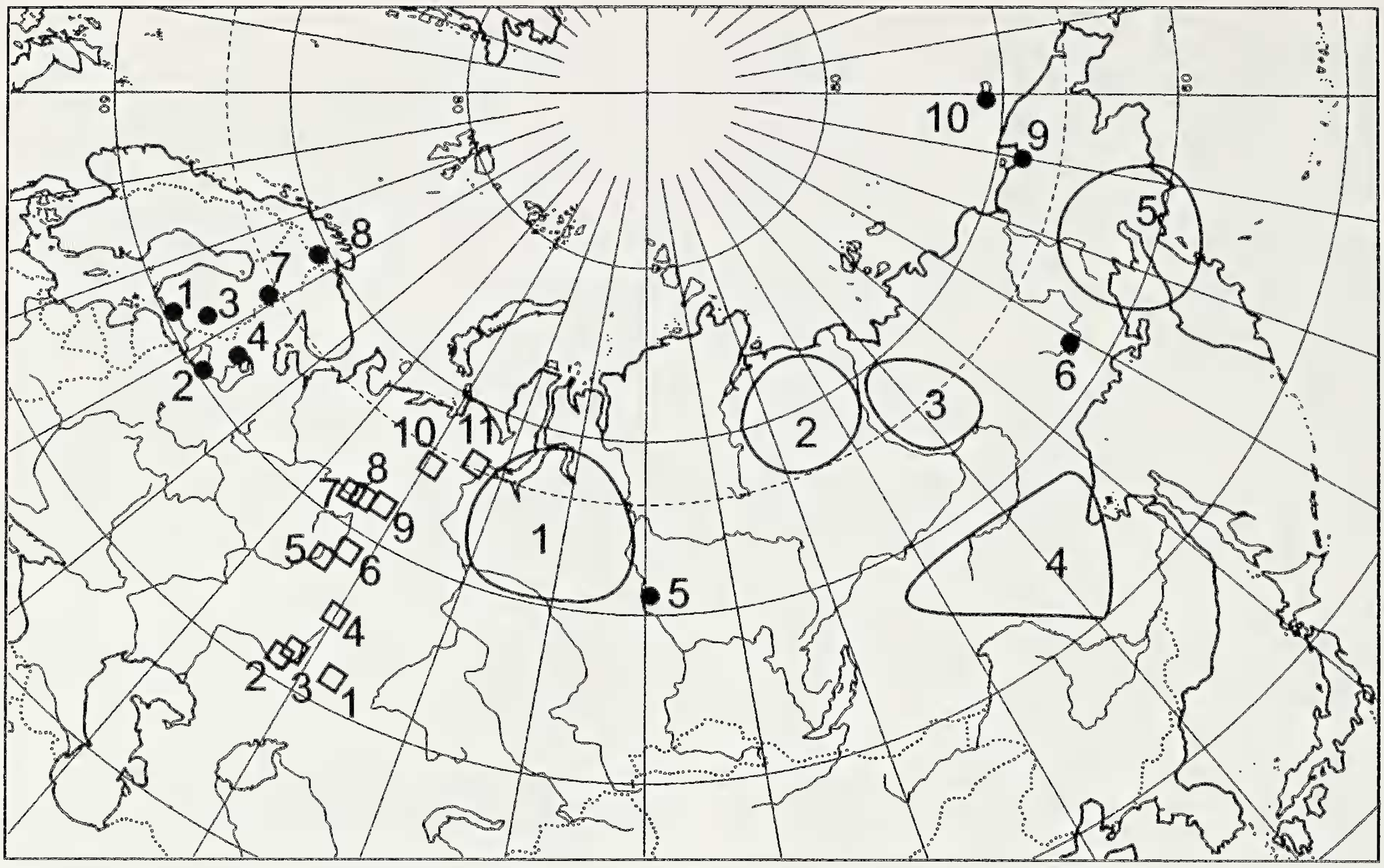

Figure 2.—Poorly known larger areas in northern Asia: 1. West Siberia; 2. Northwest Yakutia; 3. Northern Verkhoyanski and Cherski Mts; 4. North Khabarovsk and South Yakutia; 5. Koryakia. Well-studied local faunas (solid dots): 1. Tvärminne; 2. Nizhnesvirskiy; 3. Mäntyharju; 4. Kivatch; 5. Mirnoy; 6. Aborigen; 7. Kuusamo; 8. Kevo (see Table 1); 9. Chaun; 10. Wrangel. Sites in the Urals (open squares; see Table 2): 1. Troitsk; 2. Sh-Tash; 3. Bashkir Res.; 4. Ilmen Res.; 5. Preduralie Res.; 6. Basegi Res.; 7. Pechora-Lych.; 8. North Ural; 9. Lozva; 10. Cisuralia; 11. South Yamal.

larger areas of Eurasia north of 55°N does not exceed 1%.

Local faunas and indicators of diversity.—The number of species in a local fauna varies around 300 (from 240–357 species) in the boreal zone (Table 1 & Fig. 2). Tvärminne and Kevo research stations, with 425 and 165 species respectively, are at the southern and northern limits of the boreal belt in the transitional zones. Similar figures were observed in the Ural mountains (Esyunin & Efimik 1994: 240–290 species; cf. Table 2).

Some families demonstrate high fluctuation of species number and proportion within faunas compared, while the two largest families (Linyphiidae & Lycosidae) have small variation in their percentages (Tables 1–2; max./min ratio). Thus species richness of Lycosidae and Linyphiidae can be used as an indicator of the whole spider species diversity in a certain fauna. When comparing these two families in relation to absolute richness, required collecting methods and to difficulties in identification (or counting species richness) it is clear that only wolf spiders (Lycosidae) can be used as such an indicator. Linyphiidae is the most species-rich family in each local fauna, species live in all kinds of microhabitats and therefore species survey requires different collecting methods, and also the identification of linyphiids requires experience and is time consuming. Lycosidae has more species than other families, but much fewer than Linyphiidae, and lycosids are easy to collect and identify. Species richness of wolf spiders can be rather easily revealed by using pitfall traps placed in different biotopes (habitats). The percentage of lycosids in local faunas ranges from 7–12.

When comparison of faunal structure is extended south and north of the boreal zone (e.g. to Chaun Field station in south tundra, ca. 69°N, or to Wrangel Island, arctic tundra, 71°N), only lycosids fit into criteria of good indicators of diversity (see the previous paragraph). Percentages of wolf spiders in Chaun and Wrangel are 11%, while figures for Linyphiidae are more than 70%.

Table 2. Faunal structure of 11 local faunas in the Urals (only species-rich families shown) along transection (52°30′–67°N); from Esyunin & Efimik (1994); see also Fig. 2.

	Troitsk	%	Sh.-Tash	%	Bash-kir Res.	%	Ilmen Re-serve	%	Predur-alie Res.	%	Basegi Res.	%	Pe-chora Lych.	%	North Ural	%	Lozva	%	Cisur-alia	%	South Yamal	%	range of %	max./min
Araneidae	23	8	19	8	19	7	18	7	22	8	14	5	21	7	18	7	11	7	2	2	3	2	2–8	4
Clubionidae	16	6	11	4	10	4	11	5	10	4	8	3	10	3	7	3	8	5	1	1	4	3	1–6	6
Dictynidae	13	5	6	2	8	3	8	3	5	2	5	2	4	1	5	2	4	3	2	2	4	3	2–5	2.5
Gnaphosidae	22	8	14	6	20	7	16	7	11	4	17	7	17	6	13	5	3	2	5	5	8	5	2–8	4
Linyphiidae	64	24	77	31	100	36	73	29	100	37	133	51	133	46	108	43	73	46	75	66	101	66	24–66	2.8
Lycosidae	28	10	24	10	28	10	22	9	22	8	23	9	33	11	30	12	12	8	13	12	17	11	8–12	1.5
Philodromidae	12	4	10	4	8	3	10	4	12	4	7	3	8	3	7	3	5	3	3	3	3	2	2–4	2
Salticidae	24	8	20	8	23	8	21	9	18	7	12	5	12	4	14	6	9	6	3	3	3	2	2–9	4.5
Theridiidae	23	8	20	8	25	9	20	8	25	9	13	5	17	6	14	6	10	6	2	2	3	2	2–8	4
Thomisidae	22	8	20	8	15	5	18	7	13	5	10	4	9	3	11	4	10	6	4	4	5	3	3–8	2.7
Total number	271		247		281		244		269		261		290		248		158		113		154			

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